

# Multi-Solipsism

## The Physical Ontology of the Many-Minds Concept

Andrew Soltau

Abstract: The thought experiment of Wigner's friend illustrates that physical reality is different for different observers of the same world. This is now confirmed experimentally by Proietti et al. (2019). This highly counter-intuitive feature of quantum mechanics is greatly simplified in the many-minds perspective of Everett's (1957) formulation taken at face value. This provides a solution with a physical ontology.

In Lockwood (1989) the protagonist of the dynamics is the record of observations, as defined in Everett: who also specifically defines the physical observer as solely the measuring instrument. As the protagonist is a structure of information it is multiply instantiated in a great number of versions of a quasi-classical world in the universe of the unitary wave function. Since these are all coincident, the physical frame of reference of the protagonist is their superposition. The result is a 'class-of-worlds-as-a-world', by definition indeterminate where unobserved. Wigner's friend is explained in a logical manner. Schrödinger's cat is retrodicted, an inevitable feature of this type of frame of reference.

As described in QBism (Fuchs et al., 2013) the world of the protagonist is determinate solely where experienced, effectively a solipsism. As stated by Everett, solipsism fits the facts but it seems philosophically untenable because of the exclusivity. His preferred solution is no collapse. All possible worlds exist. The full explanation is a dual ontology. At the first, primitive level of logical type the universe is all possible decoherent quasi-classical worlds. At the second level it is all possible versions of a class-of-worlds-as-a-world, each one the idiosyncratic physical reality of a protagonist, a 'mind'. This defines a universal system of non-exclusive solipsisms, realities different for different agents as described in QBism. It is *these* realities that are different for different individuals who are conventionally in the same world. The term individual is here used for such protagonists, and the term observer exclusively for the physical body-mind.

# 1 The Inside View

A dualism of ontologies is inherent in the physics but has remained invisible. It is clear that there are two very different types of frame of reference in the science, but the full significance has been elusive. As will be shown, the two incompatible quantum-mechanical dynamics operate exclusively in these two domains, which are of different logical type.

As Tegmark describes:

... the development of relativity theory and quantum mechanics has taught us that we must carefully distinguish between two different views of a mathematical structure:

- The *bird perspective* or *outside view*, which is the way a mathematician views it.
- The *frog perspective* or *inside view*, which is the way it is perceived by a SAS [self-aware substructure] in it.

(1998, p. 23; emphasis in original)

This is the distinction Everett (1973) makes between absolute and relative states. In the absolute state there is no determinate outcome to any interaction because all possible states exist. On the outside view, therefore, defined by the unitary wavefunction, all possible worlds exist, each one a decoherent quasi-classical world:

The universe is constantly splitting into a stupendous number of branches, all resulting from the measurement-like interactions between its myriads of components. (DeWitt, 1970, p. 33)

For quantum mechanics, under the only interpretation to date that can lay claim to being a *realist* interpretation (the only interpretation under which we have a *serviceable* universal theory at all), appears to be saying that the world is constantly branching — if not branching into all possible worlds, then branching into all *physically* possible worlds. (Saunders & Wallace, 2008; emphasis in original)

These are the many worlds of Everett's formulation in the *physical* sense. The inside view is a completely different type of phenomenon, and the effective physical environment of this perspective is a completely different kind of thing.

The inside view is defined as the record of observations, a structure of information. This is the central feature in Everett's formulation. He defines the physical observer as the measuring instrument; and it is only: "Judged by the state of the memory" (1957, p. 462), defined as the record of observations, that the cycle of the dynamics of the standard formalism of quantum mechanics operates. So this is the protagonist of the real world in Everett's formulation, meaning the entity to which the dynamics are real ongoing operational phenomena.

This is the self-aware substructure in the world. Everett also designates it as the functional identity, meaning that by which all action is directed: this is the 'real person'. Because this SAS is a structure of information, the world of this entity is a completely different type of domain to that of the observer, of different logical type.

## 2 World Superposition

In the many-worlds universe, a specific SAS is multiply instantiated: there is a great number of slightly different versions of a quasi-classical world that contain an observer with this specific record of observations. As Deutsch states:

If, aside from variants of me in other universes, there are also multiple identical copies of me, which one am I? I am, of course, all of them. Each of them has just asked that question, 'which one am I?', and any true way of answering that question must give each one of them the same answer. (1997, 279)

In other words, all these identical copies must instantiate identically the same record of observations. Moreover, the identical observation records place all the multiple instantiations at the same location in space-time, so all are coincident. As Tegmark states:

From the bird perspective, the Level III multiverse is simple: there is only one wavefunction, and it evolves smoothly and deterministically over time without any sort of splitting or parallelism. The abstract quantum world described by this evolving wavefunction contains within it a vast number of parallel classical storylines, continuously splitting and merging, as well as a number of quantum phenomena that lack a classical description. From her frog perspective, however, each observer perceives only a tiny fraction of this full reality: she can only see her own Hubble volume (2003, p. 10)

As he goes on to say: "... decoherence prevents her from perceiving Level III parallel copies of herself." (ibid). This is obviously true for the physical observer, but the situation for the protagonist is dramatically different. Identical and coincident 'copies' of a structure of information cannot be other than a single instance, therefore there is only a single instance of the SAS in the unitary system.<sup>1</sup> This means that the effective physical environment of the protagonist is the superposition of all these worlds in which it exists. The result is a 'class-of-worlds-as-a-world', here also referred to as a 'World'. As in information technology the capitalisation denotes a class.

The physical reality very naturally assumed in the current scientific paradigm is a specific quasi-classical world, but the reality encountered by each individual

---

1 This addresses a level 3 (or 4) multiverse in Tegmark's (2003) classification, not 1 or 2.

protagonist, and thus on which experiments are carried out, is the world superposition, a World. Thus the quantum state of the effective physical environment of the individual is the quantum-mechanical sum of these worlds, here the 'quantum-mechanical frame of reference'. In this type of domain, literally a 'many-worlds reality', only what has been observed is determinate because only what has been observed is the same in all the different versions of the quasi-classical world superposed. Equally, everything not observed is the superposition of all possible ways it could be. Thus only what is defined by observations, as recorded in the state of the memory, is determinate. Thus the record of observations defines the determinacy of this type of world. This is what Vaidman defines as a 'centred world':

In this world, all objects which the sentient being perceives have definite states, but objects that are not under her observation might be in a superposition of different (classical) states. (2008)

### 3 Dual Ontologies

As Tegmark states:

Questions about parallel universes may seem to be just about as deep as queries about reality can get. Yet there is a still deeper underlying question: there are two tenable but diametrically opposed paradigms regarding physical reality and the status of mathematics, a dichotomy that arguably goes as far back as Plato and Aristotle, and the question is which one is correct.

- ARISTOTELIAN PARADIGM: The subjectively perceived frog perspective is physically real, and the bird perspective and all its mathematical language is merely a useful approximation.
- PLATONIC PARADIGM: The bird perspective (the mathematical structure) is physically real, and the frog perspective and all the human language we use to describe it is merely a useful approximation for describing our subjective perceptions. (2003, p. 12)

The great difficulty is that both seem to have considerable merit. The resolution is that both are perfectly correct, describing the two domains of different logical type. The physical reality of the outside view is the latter, and the physical reality of the inside view is the former.<sup>2</sup> It is determinate solely where observed.

Both types of frame of reference are ontologically fundamental on that specific view. There is a unilateral onticity as described in Section ... This is why the resolution has been invisible. The paradoxes are actually inside-view physics.

---

<sup>2</sup> In the frame of reference in effect, on the inside view.

## 4 QBism

This kind of world is not a new idea This is precisely the type of world addressed in Quantum Bayesianism, now known as QBism (Fuchs et al., 2013). QBism is a radical form of the Copenhagen interpretation: the effective physical environment of the protagonist is determinate solely where experienced by this protagonist. It derives from the concept that the probabilistic behaviour of matter and energy defined in the basis of quantum mechanics is Bayesian. As described by von Baeyer (2013, 51) Fuchs has demonstrated that this provides a precise match with the Born rule, the probabilistic math defining the likelihood of different observations. This would seem to confirm the Aristotelian view: reality is a QBism world. The problem has been that this had no ontology. World superposition provides the ontology for exactly his type of frame of reference and explains exactly why the Born rule should be Bayesian.

The great paradoxes, the measurement problem, nonlocality and the preferred basis, are naturally resolved by QBism. All are simply properties of a reality determinate solely where experienced. So there would seem to be significant circumstantial evidence in favour of this view. The big question is why would quantum reality be Bayesian. How can the record of observations of an individual possibly determine the probabilities of quantum events? How can we understand what this means? As Saunders poses the question: "... why should subjective probability track chance?" (2004, 2). One could say the simplest and logical answer is that there is no reality to the unobserved. This is the position of QBism, as it was of Bohr, but this seems inherently untenable from within the physicalist paradigm of modern physics. With world superposition we get both.

On the outside view the physicalist paradigm is perfectly correct. At the same time the effective physical environment of each protagonist is determinate solely where observed. Thus the World of the inside view is defined by the record of observations, which is the *basis* of Bayesian probability: the observations made and the knowledge derived. Experiments show that subjective probability tracks objective chance. The reason is *not* that the subjective is casual on the objective. It is just that the record of observations is the basis on which the class of worlds is selected.

## 5 The World Hologram

The nature of the subjective domain becomes very much more accessible once the nature of the human SAS is clearly delineated.

In humans the record of observations defines the perceptual reality, meaning the information directly experienced. Each observation takes the form of a three-dimensional virtual-reality representation of the real world observed:

Our brain constructs a three-dimensional model. It is a virtual reality in the head. (Dawkins, 1998, p. 276)

Our experience of the world is indeed a form of virtual-reality rendering which happens solely inside the brain. (Deutsch, 2011, p. 241 n.)

As Deutsch also states, it is this that is directly experienced, and this alone:

Every last scrap of our external experience is of virtual reality. (2011, p. 10).

The integrated synthesis of the record of these observations forms the full definition of the virtual reality. This is the known world of this individual: the perceptual reality in its entirety.

As Deutsch goes on to describe, this neural activity 'in here' is not experienced as such, but forms a field of information mentally projected out into space, seeming to be 'out there'. The net effect is just like that of a hologram. The virtual-reality rendering of the representation of the world is experienced as a three-dimensional field of information, mentally projected onto the three-dimensional physical world to coincide precisely. This is here termed the 'world hologram'.

The full implications of this field of information seem to be largely overlooked. Following Everett literally, this is the protagonist of the quantum mechanical dynamics. The integrated synthesis of the record of observations forms the three-dimensional virtual-reality representation of the world known. He specifically addresses the *experiences* of the observer, and defines the record of observations to be the record of *sensory* data. In other words, his formulation is an exact description of the physics of the inside view.

## 6 The Real Person

Even in the form of the world hologram the record of observations does not seem very much like a living being, a real person. Naturally, the accustomed identity is the body-mind, but if the inside view is taken to be that defined by sensory data, even the body-mind is indeterminate except where observed like everything else in the class-of-worlds-as-a-world.

In each World the determinacy is defined solely by the record of observations of the protagonist, and this includes even the body of the protagonist, the observer. Thus in this type of world, as von Baeyer states in QBism:

If I am the agent, the objective world is everything outside my mind—including other agents and even my own body. All of that I may, if I chose, treat quantum mechanically and describe by wave- functions. (2016, p. 154)

He is defining the mind here as “... my own experiences and perceptions” i.e. the world hologram. As in Lockwood's (1989) formulation the mind is defined as the record of observations.

Thus the world hologram defines both the functional identity in operation and the determinacy of the body-mind. In other words, the world hologram, Everett's record of observations, is the whole of the functional identity, a protagonist of life.

The form seems strange, a field of information defining the essential nature of a whole individual such as a human being, but a vital structure of information resides in the overall form, the self-concept. This is the record of observations of the self. This is the self-concept avatar figure, the three-dimensional representation of the protagonist, that forms the central feature of the world hologram. Just as the world hologram is the world known to the wself, the self-concept avatar figure is the self known to the self.

This known self is the reality of the individual on the inside view. The actual protagonist, however, is the whole of the world hologram: the remainder is the unconscious. All together this constitutes the real person in the world, psychologically and physically. The key point is that this field of information is the functional identity. As Everett states:

... the actions of the machine at a given instant can be regarded as a function of the memory contents only, and all relevant experience of the machine is contained in the memory (1957, p. 457)

In other words, this is the operational individual, memory, character, traits and so on. This is the definition of the conscious individual instantiated in the physical body, the self-aware substructure in reality.

This is the perceiving subject that has been rigorously excluded from the science of physics. As Mermin (2014) describes this is the origin of fundamental paradoxes in the new physics which are resolved when the perceiving subject is included. In the light of the nature of the physical reality directly encountered by the protagonist, the meaning of Schrödinger's cat is straightforward.

## 7 Schrödinger's Cat

Although the physical reality encountered, the World, is the superposition of a vast number of worlds, it *appears* to be an ordinary decoherent quasi-classical world. By definition this is the set of all worlds instantiating this specific record of observations, thus all the worlds *look* identically the same to the individual. So the net result appears to be the view of a specific quasi-classical world. The same principle applies to all classical physics experiments. The world superposition operates exactly like a specific quasi-classical world because the operation of all the superposed worlds is identically the same to observation: all yield identically the same result in this context.

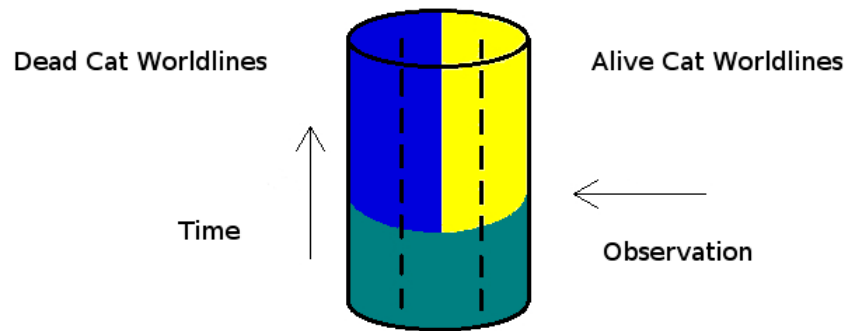


Figure 1: Parallel worlds in the Schrödinger's cat experiment, on observation.

Exactly the opposite is the case with respect to quantum physics experiments because these reveal what must be happening unobserved: there are different physical states of an object in physical reality, in the same place at the same time. This is the meaning of Schrödinger's cat (1931). The explanation is the many-worlds reality of the experimenter. Before opening the box the experimenter is present in a great number of worlds, in half of them the cat is dead and in half it survived. Then, on observation, the cat is found to be in one state or the other *because* the experimenter is, as a result, present in only half of these worlds. This is graphically illustrated in Figure 1 (Lockwood, 1989, p. 231; adapted).

There are two sets of physical worldlines, dead-cat and alive-cat. Each worldline is in a specific decoherent quasi-classical world. In the lower section, before the crucial observation is made, the world hologram of the experimenter is the same in the two sets of versions of the world: it contains no information about the current state of the cat. This therefore constitutes a single inside view. Thus the World, the effective physical environment, includes both sets of worldlines of the cat, superposed. The cat is literally both alive and dead in this frame of reference.

Once the observation is made, there are two different versions of the experimenter's world hologram, in the different sets of quasi-classical worlds corresponding to the different states of the cat. Thus the physical environment in all the worlds in the World of the experimenter now corresponds to either one state of the cat or the other. This is the enactment of the collapse dynamics, effectively, as described in detail in the following sections. Thus the nature of the World encountered retrodicts the reality of Schrödinger's cat. This is just how this type of physical reality works.



## 8 The Relative State

The surreal implication is that individuals live in different versions of physical reality in what appears to be the same world, as illustrated by Wigner's friend (1961). This has recently been confirmed in recent experimental research by Proietti et al.; different versions of the same event are the case for different observers:

This result lends considerable strength to interpretations of quantum theory already set in an observer-dependent framework and demands for revision of those which are not. (2019, abs)

As in Schrödinger's cat the world superposition presents a simple explanation. As the World encountered is determinate solely where defined by the observations made by this individual, and different individuals have made different observations, their physical realities are different. As described in QBism individuals live in personal, parallel realities:

This means that reality differs from one agent to another. This is not as strange as it may sound. What is real for an agent rests entirely on what that agent experiences, and different agents have different experiences. (Fuchs et al., 2013, p. 3 )

These are the many worlds of Everett's his formulation in the many-minds sense, each one idiosyncratic to the individual world hologram. The physical reality of each individual is defined by the record of observations, thus different individuals have different decoherent histories, and different Bayesian probabilistic definitions of the future. They are different Worlds. The explanation of Wigner's friend is that this is a second-logical-type phenomenon: two different world superpositions, two different relative states.

This is the essence of the many-minds concept. As Donald states:

Many-minds interpretation of quantum mechanics extends the many-worlds interpretation by proposing that the distinction between worlds should be made at the level of the mind of an individual observer. (1998)

Taking the mind to be the record of observations as in Lockwood (1989), it is clear that each individual lives in an idiosyncratic version of a World: each one is the class-of-worlds-as-a-world instantiating a specific world hologram. Thus the concept of world superposition provides a physical ontology for the many-minds type of interpretation.<sup>3</sup> The direct implication is 'multisolipsism', different Worlds, each one

---

<sup>3</sup> As Page (2011) proposes, what fits the facts is a "many-perceptions" interpretation, or "many-views" (Squires, 1996, p. 3). Zeh calls it: "... a multi-consciousness interpretation" (2000, p. 9; emphasis in original). The concept presented here uses the same basis as Lockwood. As he describes the preferred basis is the "consciousness basis" i.e. the world

defined solely and exclusively by a specific 'mind'.

## 9 Alternative 1

Solipsism certainly fits the facts of quantum mechanics as Everett states in his summary of the textbook formulation of quantum mechanics. It works:

It is now clear that the interpretation of quantum mechanics with which we began is untenable if we are to consider a universe containing more than one observer. We must therefore seek a suitable modification of this scheme, or an entirely different system of interpretation.

Alternative 1: To postulate the existence of only one observer in the universe. This is the solipsist position, in which each of us must hold the view that he alone is the only valid observer, with the rest of the universe and its inhabitants obeying at all times Process 2 except when under his observation.

This view is quite consistent, but one must feel uneasy when, for example, writing textbooks on quantum mechanics, describing Process 1, for the consumption of other persons to whom it does not apply. (1973, p. 6)

The interpretation to which he is referring is the standard von Neumann-Dirac formulation (1955), the operation of the two quantum mechanical dynamics in an alternating cycle as described in Section 10.

As Everett is saying here, if the quantum state is taken to be defined solely by the record of observations, the two dynamics are operating in a cycle just as the standard textbook formulation describes. Solipsism is a precise fit with the facts of quantum mechanics. Alternatives 2 to 4 do not fare so well.

## 10 Alternative 5

Everett's Alternative 5 is his new, complete departure from the established orthodoxy. There is only the linear dynamics. This also fits the facts precisely. There is no collapse; but there is the *appearance* of collapse. In other words, on the outside view there is no collapse but on the inside view there is. Thus Alternative 5 is actually the outside view *of* Alternative 1, the inside view. Alternative 5 is the world of the current paradigm, outside-view physics. Alternative 1 is the world of the inside view,

---

hologram. This is described in Section 11.

a second-logical-type phenomenon. This is inside-view physics.

At the first, primitive level of logical type, the world is the ordinary, decoherent, quasi-classical world. This is the domain of the linear dynamics. At this level the universe is the existence of all possible physical worlds of this nature. There is no collapse. That is the many-worlds theory at the physical level, as for instance described by DeWitt (ibid) and more recently Saunders & Wallace (ibid). The outside view is the physical reality of the unitary wavefunction. These are the many worlds in the physical sense. This is the universe of Alternative 5.

At the second level of logical type the universe is all possible world superpositions, each one a class-of-worlds-as-a-world. This is multisolipsism: the universe of all possible Worlds, each one the effective physical environment of a specific inside view. This is the universe of Alternative 1: idiosyncratic domains unique to the individual on the inside view. The dynamics cycle as described in textbook quantum mechanics.

## 11 The Textbook Cycle

This provides a readily accessible visualisation of the textbook cycle, and an explanation of the measurement problem in terms of pure logic. The standard von Neumann-Dirac formulation of quantum mechanics defines a cycle of the operation of the two dynamical laws:

Process 1: If a measurement is made, then the system instantaneously and randomly jumps to a state where it either determinately has or determinately does not have the property being measured.

Process 2: If no measurement is made, then the system evolves continuously according to the linear, deterministic dynamics. (Barrett, 2008; adapted)

The linear dynamics, Process 2, operates within the context of a specific quantum-mechanical frame of reference, defined by a specific quantum state. The definition of the positions and states of fundamental particles change with the advance of the time parameter, as defined by the wave function. As this enactment progresses, the next observation is formulated in the physical apparatus of the observer. At the point where this is experienced and added to memory, the definition of the world hologram alters; and as a result the individual is defined as existing in a different class-of-worlds-as-a-world, all the worlds in which this event has determinately happened. Thus the frame of reference evolves to become a different quantum-mechanical frame of reference.

The observer operates according to the linear dynamics. While following the linear dynamics defined by the physical world of the observer, the world hologram operates according to the collapse dynamics.

These two dynamics, collapse and linear, operate at different levels of logical type, as illustrated in Figure 2 below. Each of the green space-time images represents the domain of a specific quantum state, a 'snapshot' of the world in the quantum concept of time as described by Deutsch (1997, p. 278).

The linear dynamics is illustrated by the white arrows, operating within the context of a specific quantum-mechanical frame of reference: things move and change as defined by the wave function. As this system functions the next observation is made, and the definition of the world hologram alters. As a result the individual is defined as existing in a different snapshot of the world, defined by a different quantum state, as illustrated by the black arrows. Effectively, on the inside view, this is the effective change of the quantum state: the collapse dynamics, Process 1.

This is a completely different type of phenomenon to the linear dynamics because it is operating at a higher level of logical type, *contextual* to a specific snapshot, a specific space-time layout of matter and energy, defined by a specific quantum state. As Lockwood states, this is a: "... dimension running, so to speak, *perpendicular* to time and space." (1989, p. 232; emphasis added).<sup>4</sup>

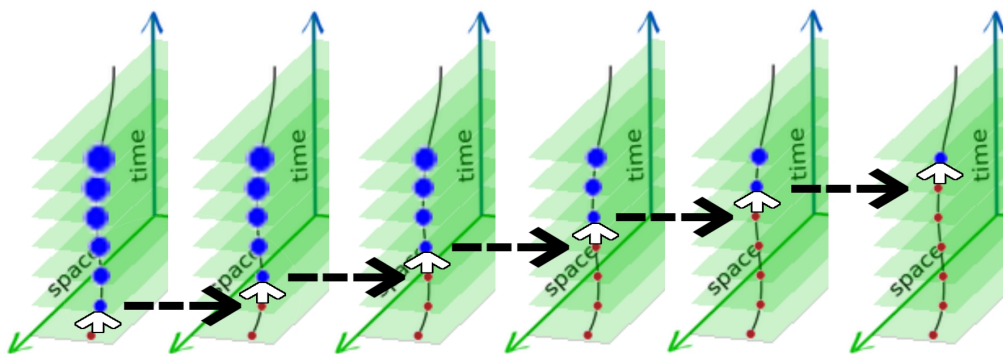


Figure 2: A sequence of snapshots in the quantum concept of time.

On the inside view the collapse dynamics is enacted and a specific state realised. On the outside view all possibilities continue to exist. On *this* view collapse is a virtual phenomenon: it only appears to happen. As Everett states, referring to the standard formulation :

4 Only one black arrow is shown at each transition in Figure 2 as an example, but in reality there would be a great profusion of these transitions, the arrows 'spreading out' in all directions in this perpendicular dimension. As Lockwood continues: "This dimension can be thought of as of arbitrary finite size, and divided into as many regions as there are eigenstates of the corresponding observable, each with a size that is proportional to the square modulus of the coefficient associated with the corresponding eigenstate, as it figures in the superposition." (ibid).

... we were able to show that all phenomena will *seem* to follow the predictions of this scheme to any observer. (1973, p. 110; emphasis in original)

The linear dynamics operates within one physical snapshot. The collapse dynamics operates the sequence of snapshots. This is the explanation of the duality of function in the quantum formalism. The incompatible dynamics operate at different levels of logical type.<sup>5</sup>

It is the frame of reference of the individual protagonist that makes sense of this bi-level context. Rather than one monolithic world, a world governed by the linear dynamics of the wave function in which collapse somehow happens, reality is a multisolipsism. The linear dynamics is the fundamental dynamics, but it is altered, in each individual, idiosyncratic frame of reference of a protagonist, as each observation is made. This is what makes sense of the incompatible dynamics in the standard von Neumann-Dirac formulation of quantum mechanics.

## 12 The Preferred Basis

The decoherent quasi-classical world of the current paradigm is the obvious assumption if we accept the many-worlds formulation; and as Carroll describes, this lays to rest all kinds of problems including that of measurement:

The Many-Worlds formulation of quantum mechanics removes once and for all any mystery about the measurement process and collapse of the wave function. We don't need special rules about making an observation: all that happens is that the wave function keeps chugging along in accordance with the Schrödinger equation. And there's nothing special about what constitutes 'a measurement' or 'an observer' – a measurement is any interaction that causes a quantum system to become entangled with the environment, creating a branching into separate worlds, and an observer is any system that brings about such an interaction. Consciousness, in particular, has nothing to do with it. The 'observer' could be an earthworm, a microscope or a rock. There's not even anything special about macroscopic systems, other than the fact that they can't help but interact and become entangled with the environment. The price we pay for such a powerful and simple unification of quantum dynamics is a large number of separate worlds. (2019)

---

<sup>5</sup> A similar logic can be applied to the physical observer as described in Section 11. Decoherence gives rise to specific determinate quasi-classical worlds, but it may well be considered that the observer, 'having no hair', is nonetheless correlated with a class of worlds. This gives rise the type of universe defined in Rovelli's (1996) relational quantum mechanics.

This, however, is not a complete solution. The remaining problem is the lack of a proper definition of the frame of reference, meaning the effective physical environment to which the net result applies: 'the world'. This is the preferred basis problem, the question of on what basis exactly physical reality is defined.

On the outside view the basis is the components of classical physics, location, momentum and so on. As Tegmark states:

Decoherence also explains why states resembling classical physics have special status: they are the most robust to decoherence. (2007, p. 2)

Decoherence is why there are such things as quasi-classical worlds in which the definition of macroscopic physical reality is given by classical physics. This, however, does not resolve the preferred basis problem. As Barrett quips:

Making the total angular momentum of all the sheep in Austria determinate by choosing such a preferred basis to tell us when worlds split, would presumably do little to account for the determinate memory I have concerning what I just typed. But this is the problem, we do not really know what basis would make our most immediately accessible physical records, those records that determine our experiences and beliefs, determinate in every world. (2008)

The determinate memory is the world hologram, the inside view. The puzzle is on what basis would reality have to be defined, on the outside view, in order to ensure that the inside view was determinate in every case. The problem is that no physical basis works.

What does work is a 'consciousness basis' as Lockwood demonstrates, the "... preferred set of brain observables" (2005. p 234). This is taking the record of observations itself as the basis, the world hologram. This, however, is not because the world hologram defines the physical reality in conventionally causal manner, it is solely a set-selection phenomenon. The worlds in the class-of- worlds-as-a-world are selected on the basis that they instantiate the world hologram, and in this context the world hologram is effectively the determinant because the record of observations defines the determinacy. This is why the record of observations, in humans the world hologram, is ontologically fundamental on this view, despite the seeming oxymoron.

Once this different *type* of physical frame of reference is brought in, the logic is straightforward. The consciousness basis is the inside-view basis, and the physical reality is the class-of-worlds-as-a-world, a second-logical-type phenomenon.

It means that there is an ontological dualism. There are two different ontological bases, at the two different levels of logical type. The two different types of quantum-mechanical dynamics operate in the two different types of frame of reference. It is not hard to see why this has been deeply obscure. The basis at each level of logical type is the basis at that level only. In other words there are dual, *unilateral* ontologies. At the first primitive level of logical type the universe is all possible quasi-classical worlds,

the basis being classical physical observables. At the second it is a class-of-worlds-as-a-world, the basis being the record of observations, Lockwood's consciousness basis.

## 13 Relational Quantum Mechanics

The consciousness basis described above is essentially the one Everett is describing in his text: he refers to experience and sensory data. As Barrett states, however, Everett's formulation can be read at either level, physical or experience:

Note that Everett did not require a physically preferred basis to solve the determinate record problem to show that pure wave mechanics was empirically faithful. The principle of the fundamental relatively of states explicitly allows for arbitrarily specified decompositions of the absolute universal state into relative states. (2008)

The relative state of Everett's formulation can be visualised at the physical level using the same logic as applied to the inside view defined by sensory data. A physical observer is naturally assumed to exist in a specific quasi-classical world. However, if Everett is taken at face value the result is a world superposition at this level also.

The relative state is defined solely by the correlations established by observations. For any given observer this must mean it is correlated with all quasi-classical worlds in which the interactions of observation with an observer of this definition took place.

It seems obvious that a specific observer is in a specific quasi-classical world, but an object defined by a quantum state 'has no hair', meaning it is not meaningful to refer to two identical bodies with identical quantum states, especially in the same place at the same time. So the argument is the same as for the world hologram above. A particular body is instantiated in many versions of a quasi-classical world, all coincident. Thus the body is not only correlated with them all but actually in them all: hence world superposition for the physical observer.

In this frame of reference the physical reality is defined solely by correlations with the observer. World superposition explains this peculiar state of affairs because anything not correlated with the observer is a superposition of all possible states. This explains how physical reality is different for different physical observers, hence the observer-dependent world at the level of the physical observer as originally described in Wigner's friend, and now confirmed by Proietti et al. (ibid). This gives rise to the universe of relational quantum mechanics as defined by Rovelli (1996). Different observers live in different world superpositions: each relative state is a different class-of-worlds-as-a-world. The result is a purely relative state with each frame of reference defined with respect to the observer. As Rovelli states:

... a quantum mechanical description of a certain system (state and/or

values of physical quantities) cannot be taken as an “absolute” (observer independent) description of reality, but rather as a formalization, or codification, of properties of a system *relative* to a given observer. (1996, p. 6; emphasis in original)

The argument seems easier to follow in the case of the physical reality of the world hologram, when the two types of physical reality have different bases. The major difference is that the physical reality of the inside view, the World, is effectively transtemporal, within the context of the static domain of the universe of all possible worlds. Given simply a moving frame of reference at the sensory level the equations of physics come to life as described in Section 10.

## 14 Conclusion

In the many-minds concept the distinction between worlds is made at the level of the mind of an individual observer. In Lockwood's (1989) formulation the mind is defined by the record of observations. This is the entity Everett demonstrates to be the protagonist, meaning the entity to which the dynamics of physics are real operational phenomena. He also designates it as the functional identity, meaning that by which all action is directed. The term individual is used here to refer to this protagonist.

This structure of information is deeply familiar to every conscious individual. This is the perceptual reality, the experience of the present moment in the world combined with all the experiences of the past. It is a virtual reality. As Dawkins (1998) states quoted above, the brain constructs a three-dimensional model of the world, a virtual reality. In other words, the integrated synthesis of the record of observations forms the three-dimensional virtual-reality representation of the world known from observations. As Deutsch (*ibid*) describes, this is mentally projected to coincide with the real world perceived in a holographic manner: here the world hologram.

For *this* kind of entity, physical reality is a QBism type world, determinate solely where experienced. The ontology emerges naturally from the nature of the protagonist. This field of information is multiply instantiated in the many worlds, and all are coincident. Thus the effective physical environment of the protagonist is superposed sum of these worlds, a class-of-worlds-as-a-world. This is by definition indeterminate except where defined by the record of observations experienced: all else is the superposition of all possible variations. Thus the world hologram defines the determinacy of the effective physical environment, the world superposition.

As Deutsch (*ibid*) describes, this entity defines all the characteristics and processes of the individual. This is in some sense the real person – but it is just a spatially distributed field of information, albeit with extraordinary properties. This nonetheless defines the human form as determinate in this frame of reference. At the centre of the world hologram is the self-concept avatar figure.



The world hologram is the inside view of the universe as defined by Tegmark (1998). It is also what he calls the self-aware substructure in the world, here the individual. The rest of the body-mind is external to this self: as von Baeyer (2016) states quoted above, the objective world is everything apart from the experiences and perceptions, the world hologram. Since only this is determinate in this frame of reference, this is the only determinate definition of the real person in the world.

Since the world hologram defines the determinacy of the effective physical environment, the class-of-worlds-as-a-world, the self is the same thing as the determinacy of the physical reality encountered, the real world. As everything apart from that defined by the world hologram – the mind in Lockwood's formulation – is indeterminate, this is a genuine solipsism.

As Everett describes in his first potential solution to the quantum paradoxes, Alternative 1, solipsism, fits the facts of quantum mechanics precisely. In the world of the protagonist, defined as the record of observations, the cycle of the standard formulation operates naturally. This is the operation of the reality of the frame of reference of the inside view. Naturally, the world hologram follows the linear dynamics of the world of the observer, as it must, but as each observation is made it operates the collapse dynamics at a different level of logical type: the change in the definition of the class-of-worlds-as-a-world.

Everett opts for Alternative 5: there is no collapse. All possible worlds exist – but there is the *appearance* of collapse. In other words there is the appearance of Alternative 1, the domain in which each observation alters the quantum-mechanical frame of reference. Meanwhile, on the inside view, Alternative 1 is the reality. Everett's Alternative 5 is simply the outside view of Alternative 1. It means multisolipsism.

Were it to be taken seriously, the original concept of solipsism would be a philosophy of despair, a world devoid of companionship or even genuine interaction. Multisolipsism is very different. It does not mean that other people do not exist, or that the real world does not exist. Other individuals encountered in the world are all perfectly real, but they live in parallel realities, idiosyncratic physical domains, slightly different versions of the quantum mechanical frame of reference. The world of each individual is nonetheless ultra-real, a class-of-worlds-as-a-world.

The solipsisms are coexistent, and they share common ground. Naturally, such realities can often be the same with regard to the current location. With respect to two individuals standing next to each other and making essentially the same observations, their physical realities are of course the same – with regard to this environment at the present moment. Nonetheless, the Bayesian definition of each of their realities is different. This is where the practical implications are deeply at odds with the current paradigm. This peculiar logic is produced by the overlapping *classes* of quasi-classical worlds. This is the domain of second-logical-type phenomena and inside-view physics.

Objectively, multiple observers live together in a specific quasi-classical world. Subjectively, however, on the inside view, each conscious individual has a different quantum-mechanical frame of reference, thus the trajectory in the quantum concept of time is different for each individual. Bayesian probability operates on an idiosyncratic basis, defined by the quantum-mechanical frame of reference of each individual. This is the dynamics of inside-view physics, the physics of a class-of-worlds-as-a-world. Each solipsism is a personal, physical, parallel reality, idiosyncratic in definition. Nonetheless, of course, other people are also perfectly real. The dualism means that individuals exist in isolation but communicate and interact globally. This is multisolipsism.

## References

- Barrett, J.: 2008, "Everett's Relative-State Formulation of Quantum Mechanics", available at <http://stanford.library.sydney.edu.au/archives/spr2008/entries/qm-everett/>
- Carroll, S.: 2019, "Splitting the Universe", Aeon, Weintraub, P. (ed), <https://aeon.co/essays/how-the-many-worlds-theory-of-hugh-everett-split-the-universe>
- Dawkins, R.: 1998, *Unweaving the Rainbow*, Houghton Mifflin, Boston.
- Deutsch, D.: 1997, *The Fabric of Reality*, Allen Lane, London.
- Deutsch, D.: 2011, *The Beginning of Infinity*, Viking Books, New York.
- DeWitt, B.: 1970, "Quantum Mechanics and Reality", *Physics Today*, 23: 30–35.
- Donald, M.: 1998, "A Many-Minds Interpretation Of Quantum Theory", available at: <http://people.bss.phy.cam.ac.uk/~mjd1014/>
- Everett, H.: 1957, "'Relative State' Formulation of Quantum Mechanics", *Reviews of Modern Physics* 29: 454-462.
- Everett, H.: 1973, "The Theory of the Universal Wave Function", in DeWitt, B. & Graham, N. (eds), *The Many-Worlds Interpretation of Quantum Mechanics*, Princeton University Press: 3-140.
- Fuchs, C., Mermin, N. & Schack, R.: 2013, "An Introduction to QBism with an Application to the Locality of Quantum Mechanics", available at: [arxiv.org/abs/1311.5253](http://arxiv.org/abs/1311.5253)
- Lockwood, M.: 1989, *Mind, Brain and the Quantum*, Blackwell, Oxford.

- Lockwood, M.: 2005, *The Labyrinth of Time*, Oxford University Press.
- Mermin, D.: 2014, "Physics: QBism puts the scientist back into science", *Nature*, Vol. 507, No. 7493. (26 March 2014), pp. 421-423
- Page, D.: 2011, "Consciousness and the Quantum", available at: [arxiv.org/abs/1102.5339v1](http://arxiv.org/abs/1102.5339v1)
- Proietti, M. Pickston, A. Graffitti, F. Barrow, P. Kundys, D. Branciard, C. Ringbauer, M. & Fedrizzi, A.: 2019, "Experimental rejection of observer-independence in the quantum world", available at: <https://arxiv.org/abs/1902.05080>
- Rovelli, C.: 1996, "Relational Quantum Mechanics", available online at <http://arxiv.org/abs/qant-ph/9609002> .
- Saunders, S. & Wallace, D.: 2008, "Branching and Uncertainty ", available at <http://philsci-archive.pitt.edu/3811/>
- Schrödinger, E.: 1935, "The Present Situation in Quantum Mechanics", *Proceedings of the American Philosophical Society*, 124, 323–338 (1984) (Translated by J. Trimmer from "Die gegenwärtige Situation in der Quantenmechanik", *Naturwissenschaften* 23 (49): 807–812.)
- Squires, J.: 1996, "What are quantum theorists doing at a conference on consciousness?", available at <http://arxiv.org/abs/quant-ph/9602006v1>
- Tegmark, M.: 1998, "Is "the theory of everything" merely the ultimate ensemble theory?", available at <http://arxiv.org/abs/gr-qc/9704009v2>
- Tegmark, M.: 2003, "Parallel Universes", available at: [arxiv.org/abs/astro-ph/0302131v1](http://arxiv.org/abs/astro-ph/0302131v1)
- Tegmark, M.: 2007, "Many Lives in Many Worlds", *Nature*, 448, 23, July 2007, available at <http://arXiv.org/abs/0707.2593v1>
- Vaidman, L.: 2008, "Many-Worlds Interpretation of Quantum Mechanics", *The Stanford Encyclopedia of Philosophy* (Fall 2008 Edition), Zalta, E. (ed.), available at: [plato.stanford.edu/archives/fall2008/entries/qm-manyworlds/](http://plato.stanford.edu/archives/fall2008/entries/qm-manyworlds/)
- von Baeyer, H.: 2016, *Qbism: The Future of Quantum Physics*, Harvard University Press.
- von Neumann, J.: 1955, *Mathematical Foundations of Quantum Mechanics*, Princeton: Princeton University Press. (Translated by R. Beyer from *Mathematische Grundlagen der Quantenmechanik*, Springer: Berlin, 1932.)
- Wigner, E.: 1961, "Remarks on the mind-body question", in *Symmetries and Reflections*, in I. J. Good, ed. *The Scientist Speculates*, Basic Books, New York.
- Zeh, H.: 2000, "The Problem of Conscious Observation in Quantum Mechanical Description", available at <https://arxiv.org/pdf/quant-ph/9908084.pdf>